Details of each benchmark line

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Details (fail safe note) for each of my analyses.

$$\tilde{l}_\mathrm{L} = (\tilde{e}_\mathrm{L}, \tilde{\mu}_\mathrm{L}, \tilde{\tau}_\mathrm{L}), \qquad \tilde{\nu} = (\tilde{\nu}_e, \tilde{\nu}_\mu, \tilde{\nu}_\tau), \qquad \text{slepton} = (\tilde{l}_\mathrm{L}, \tilde{\nu}, (\tilde{l}_\mathrm{R})),$$
$$l = (e, \mu, \tau), \qquad \ell = (e, \mu), \ldots$$

1. Decay chain and accepted signal categorization

We label decay chains as

$$\text{chain-3L} : \tilde{\chi}^0\tilde{\chi}^\pm \to \left[\left(\tilde{l}_\mathrm{L}^{(*)} l^{(*)}, \tilde{\nu}^{(*)}\tilde{\nu}^{(*)}; 1/12 \text{ each}\right)\left(\tilde{\nu} l, \tilde{l}_\mathrm{L}\nu; 1/6 \text{ each}\right)\right] \otimes (\text{slep} \to \text{lep}\tilde{\chi}^0_\mathrm{LSP}; 100\%) \tag{1.1}$$
$$\text{chain-LLT} : \tilde{\chi}^0\tilde{\chi}^\pm \to \left[\left(\tilde{l}_\mathrm{R}^{(*)} l^{(*)}; 1/6 \text{ each}\right)\left(\tilde{\tau}_\mathrm{R}\nu; 100\%\right)\right] \otimes (\text{slep} \to \text{lep}\tilde{\chi}^0_\mathrm{LSP}; 100\%) \tag{1.2}$$
$$\text{chain-WZ} : \tilde{\chi}^0\tilde{\chi}^\pm \to (Z\tilde{\chi}^0_\mathrm{LSP})(W^\pm\tilde{\chi}^0_\mathrm{LSP}) \quad \text{(possibly virtual)}, \tag{1.3}$$
$$\text{chain-WH} : \tilde{\chi}^0\tilde{\chi}^\pm \to (H\tilde{\chi}^0_\mathrm{LSP})(W^\pm\tilde{\chi}^0_\mathrm{LSP}) \quad \text{(possibly virtual)}, \tag{1.4}$$

and selection criteria as[*1]

$$\text{sig-3L} : (3\ell)_\mathrm{SFOS} \tag{1.5}$$
$$\text{sig-LLT} : (2\ell)_\mathrm{SFOS} + \tau_\mathrm{had} \tag{1.6}$$
$$\text{sig-SS2L} : (2\ell)_\mathrm{SS} + \tau_\mathrm{had} \tag{1.7}$$

ATLAS1803 analyzes chain-3L ($x = 0.5$) by sig-3L ("a statistical combination of the five SR3-slep regions."); note that the lepton ℓ may as well come from leptonic tau decays.

CMS1709 has several analyses; relevant ones are

- chain-3L ($x = 0.5$) by sig-3L,
- chain-3L ($x = 0.05, 0.95$) by sig-SS2L×3L (×: statistical combination),
- chain-LLT ($x = 0.05, 0.5, 0.95$) by sig-3L×LLT,
- chain-WZ by sig-3L,
- chain-WH by combination of various SRs.

2. tab1-0.50

This line is characterized by

$$M_2 = \mu = 2M_1, \quad x = \frac{m_{\tilde{l}_\mathrm{L}} - m_{\tilde{\chi}^0_1}}{m_{\tilde{\chi}^0_2} - m_{\tilde{\chi}^0_1}} = 0.5, \quad \tan\beta = 40, \quad \tilde{l}_\mathrm{R}, \tilde{q}, \text{heavy-Higgs: decoupled.} \tag{2.1}$$

The mass spectrum is shown below, and we use $m_{\tilde{\chi}^\pm_1}$ (in GeV) as the label of each model point.

P<300 is not considered in our analysis, as neither by ATLAS. P150 has $\tilde{\nu}$-LSP.

In P≥300, $\tilde{\chi}^0_2\tilde{\chi}^\pm_1$ mainly produces chain-3L. Also, $\tilde{\chi}^0_{3,4}$ and $\tilde{\chi}^\pm_2$ decays similarly. We safely ignore $\tilde{\chi}^0_3$ because of non-degeneracy and, as it has less $\tilde{W}$-component, smaller production rate. A degenerate pair

[*1] "SF", "OS", "SS" are respectively for same flavor, opposite sign, and same sign. $(3\ell)_\mathrm{SFOS}$ means that two of them form a SFOS pair and the other is arbitrary. Particles are "hard" (not soft) unless noted as such. Events with extra leptons are vetoed in some analyses, but I do not care those vetoes as we are anyway not interested in vetoed signatures.

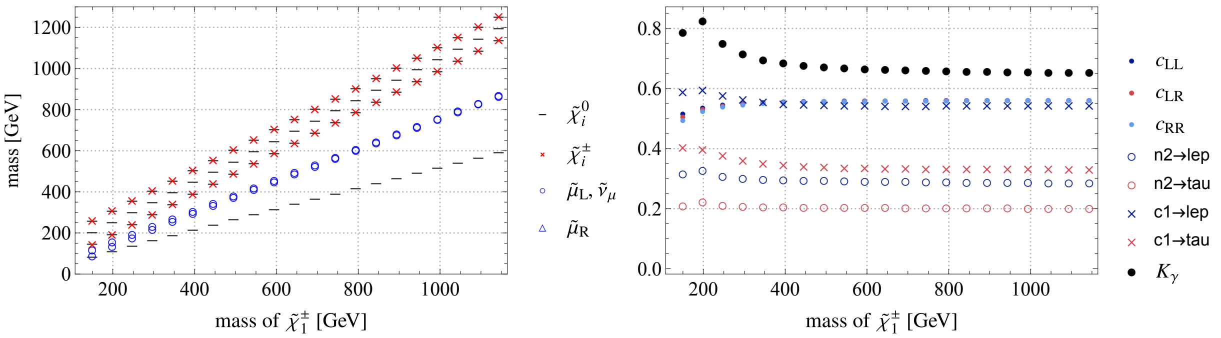

Figure 1: Mass spectrum and c-factors of tab1-0.50 benchmark line. The models are generated with $M_2 = 200, 250, \ldots, 1200\,\mathrm{GeV}$, while $m_{\tilde{\chi}_1^\pm}$ is used to label.

$\tilde{\chi}_4^0\tilde{\chi}_2^\pm$ may serve as the chain-3L target. At this first stage I will ignore it, but it may be interesting to include the effect (but how?).

The c-factors are similar and thus we use the factor

$$K_\sigma = \mathrm{mean}(c_{\mathrm{LL}}, c_{\mathrm{LR}}, c_{\mathrm{RR}}) \tag{2.2}$$

to compensate the difference in production cross section from pure-wino (ATLAS 1803) case. We thus estimate the production cross section as

$$\sigma(pp \to \tilde{\chi}_2^0\tilde{\chi}_1^\pm) \approx K_{\mathrm{sigma}} \cdot \sigma(pp \to \tilde{W}^\pm\tilde{W}^3), \tag{2.3}$$

where the pure-wino production cross section $\sigma(pp \to \tilde{W}^\pm\tilde{W}^3)$ is taken from LHCSUSYXSWG[*2].

The decays of $\tilde{\chi}_2^0\tilde{\chi}_1^\pm$ does not equally branch because of Yukawas and slepton mass differences;

$$\tilde{\chi}_2^0: \quad \tau > e = \mu \gtrsim \nu_e = \nu_\mu = \nu_\tau \quad \text{(also to } Z,\, H\text{)}, \tag{2.4}$$

$$\tilde{\chi}_1^\pm: \quad \tau > e = \mu \gtrsim \nu_\tau \gtrsim \nu_e = \nu_\mu \quad \text{(also to } W^\pm\text{)}, \tag{2.5}$$

while in ATLAS analysis they are universal since they consider wino-like $\tilde{\chi}_2^0\tilde{\chi}_1^\pm$ with degenerate sleptons. As seen from Eq. (A.1), this non-universality is compensated by

$$K_\Gamma = \frac{1}{0.269}\left[p(\tilde{\ell}_{\mathrm{L}}, \tilde{\nu}_\ell|\tilde{\chi}_1^\pm) + \frac{1}{2}p(\ell|\tau)p(\tilde{\tau}_{\mathrm{L}}, \tilde{\nu}_\tau|\tilde{\chi}_1^\pm)\right]\left[p(\tilde{\ell}_{\mathrm{L}}^{(*)}|\tilde{\chi}_2^0) + \frac{1}{2}p(\ell|\tau)^2 p(\tilde{\tau}_{\mathrm{L}}^{(*)}|\tilde{\chi}_2^0)\right] \tag{2.6}$$

(the notation $p(\text{daughters}|\text{mothers})$ should be understood). Here one should note that we ignore the kinematics difference due to the origin of lepton (whether τ, $\tilde{\chi}$, or sleptons) as well as slepton non-degeneracy.

We then compare our cross section with σ_{UL}; the points with

$$\frac{K_\sigma K_\Gamma \cdot \sigma(pp \to \tilde{W}^\pm\tilde{W}^3)}{\sigma_{\mathrm{UL}}} \geq 1 \tag{2.7}$$

are excluded.[*3]

The results against ATLAS1803 is shown in Fig. 2, where the black dots correspond to $K_\sigma K_\Gamma \sigma(\text{Wino})$. It shows that the ATLAS1803 analysis nearly excludes below $\sim 860\,\mathrm{GeV}$. The wiggles in σ_{UL} is due to interpolation of the σ_{UL}-grid ATLAS provides, for which logarithmic interpolation (i.e., linear interpolation on the function $\log \sigma_{\mathrm{UL}}(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0})$) is used.

A. N2C1 acceptance

The acceptance of N2C1-to-slep events in relevant selection criteria is summarized here.

[*2] https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections13TeVn2x1wino
[*3] ATLAS 1803: https://doi.org/10.17182/hepdata.81996.v1/t80

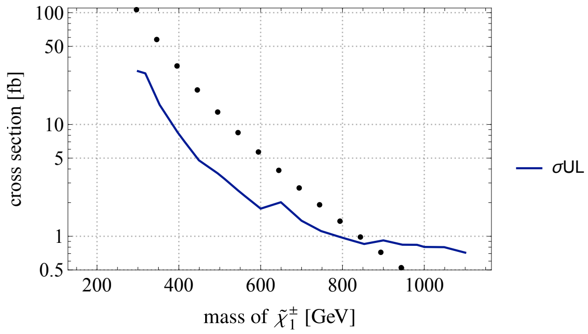

Figure 2: ATLAS 1803 analysis (3l-slep) on tab1-0.50 benchmark line.

Noting that sig-3L requires 3ℓ with SFOS pair, the probability that chain-3L with $x = 0.5$ produces signatures falling in sig-3L category is estimated by

$$A(\text{sig-3L}|\text{chain-3L}_{x=0.5}) \approx \left[p(\tilde{\ell}_\mathrm{L}, \tilde{\nu}_\ell|\tilde{\chi}_1^\pm) + p(\ell|\tau)p(\tilde{\tau}_\mathrm{L}, \tilde{\nu}_\tau|\tilde{\chi}_1^\pm)\right]\left[p(\tilde{\ell}_\mathrm{L}^{(*)}|\tilde{\chi}_2^0) + \frac{1}{2}p(\ell|\tau)^2 p(\tilde{\tau}_\mathrm{L}^{(*)}|\tilde{\chi}_2^0)\right] \tag{A.1}$$

$$= \left(\frac{4}{6} + \frac{2}{6}p(\ell|\tau)\right)\left(\frac{4}{12} + \frac{1}{2}p(\ell|\tau)^2\frac{2}{12}\right) = 0.269, \tag{A.2}$$

where $p(\ell|\tau) \simeq 0.352$ is the leptonic decay rate of τ.

References